U. S. NAVAL HOSPITAL
NATIONAL NAVAL MEDICAL CENTER
BETHESDA, MARYLAND

HISTORICAL RECORD
OF THE
NUCLEAR REACTOR FOR MEDICINE AND RESEARCH

DEDICATED

15 NOVEMBER 1957

REAR ADMIRAL BARTHOLOMEW W. HOGAN, MC, USN

Surgeon General, United States Navy

REAR ADMIRAL THOMAS F. COOPER, MC, USN

Commanding Officer, National Naval Medical Center

Bethesda, Maryland

CAPTAIN EDWARD C. KENNEY, MC, USN

Commanding Officer, U. S. Naval Hospital

Bethesda, Maryland

Reactor Administrator

CAPTAIN ROBERT W. SCHEPERS, CEC, USN

District Public Works Officer

Potomac River Naval Command

Officer in Charge of Construction

15 November 1957

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Chief, Radiological Service
U. S. Naval Hospital, Bethesda, Maryland

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15 November 1957

NUCLEAR REACTOR PROJECTS COMMITTEE

Captain E. Richard King, MC, USN, Chairman
Commander Thomas E. Shea, Jr., MSC, USN
Commander Francis W. Chambers, Jr., MSC, USN
Lieutenant Commander Henry C. Besmen, CEC, USN
Lieutenant Thomas G. Mitchell, MSC, USN

REACTOR APPLICATION'S COMMITTEE

Captain E. Richard King, MC, USN
Captain John B. MacGregor, MC, USN
Captain Vernon E. Martens, MC, USN
Commander Francis W. Chambers, Jr., MSC, USN
Lieutenant Thomas G. Mitchell, MSC, USN

REACTOR HAZARDS COMMITTEE

Commander Thomas E. Shea, Jr., MSC, USN
Commander Francis W. Chambers, Jr., MSC, USN
Commander Royce Skow, MSC, USN
Lieutenant Robert Sharp, MSC, USN
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NUCLEAR MEDICINE COMMITTEE

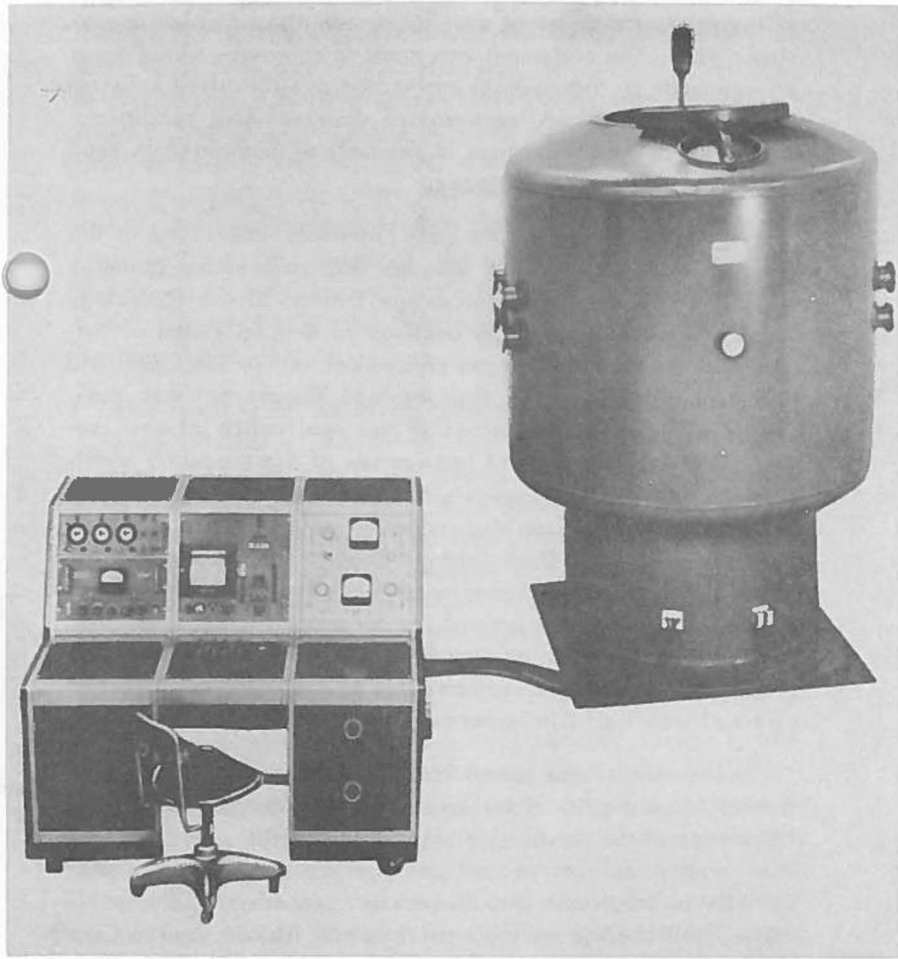
Captain Edward C. Kenney, MC, USN, Chairman
Captain Calvin B. Galloway, MC, USN
Captain Vernon E. Martens, MC, USN
Captain S. Francis Williams, MC, USN
Captain John B. MacGregor, MC, USN
Captain E. Richard King, MC, USN
Captain Richard B. Williams, Jr., MC, USN
Captain John B. Ferris, DC, USN
Commander Francis W. Chambers, Jr., MSC, USN

LICENSED MEDICAL NUCLEAR REACTOR OPERATORS

Captain E. Richard King, MC, USN
Commander Thomas E. Shea, Jr., MSC, USN
Commander Francis W. Chambers, Jr., MSC, USN
Lieutenant Armand R. Nice, MSC, USN
Lieutenant Robert Sharp, MSC, USN
Lieutenant Thomas G. Mitchell, MSC, USN
Lieutenant James W. Duckworth, MSC, USN

15 NOVEMBER 1957

THE 5 WATT REACTOR FOR MEDICINE AND RESEARCH AT THE U. S. NAVAL HOSPITAL, BETHESDA, MARYLAND--- 1957



HISTORICAL RECORD

I. BACKGROUND

It has been said that the period from the end of World War II to the present date might well be termed, "the Golden Age of Medicine." The statement was made in reference to the great strides made by the medical profession and its allied sciences in the diagnosis and treatment of diseases and conditions. Among these great advances in the field of medicine has been the use of radioactive isotopes.

The Naval Hospital has been intensely interested in the diagnosis and treatment of disease with radioactive isotopes since 1948 when the Radioisotope Branch of the Radiology Service was organized. In addition to the daily use of currently accepted radioisotope procedures in the diagnosis and treatment of disease the Radioisotope Department has conducted clinical investigations in the application of new isotopes or newer methods of application of the presently available isotopes in the diagnosis and treatment of disease. With the recent emphasis on the reduction of total body radiation from any source the Radioisotope Department became interested in the utilization of shorter half life isotopes in human application. Under past procedures for procuring isotopes from central agencies such as Oak Ridge, it was almost mandatory to use longer half life isotopes due to the rapid deterioration of the shorter half life isotopes during transit.

The staffs of the Naval Hospital and the Naval Medical School, working in close association with the other three commands of the Naval Medical Center, obtains and utilizes the various radioactive isotopes that have become accepted for use in treatment and diagnostic procedures. These isotopes have become more plentiful as the Atomic Energy Commission has authorized more atomic reactors. In fact, since the original endeavors of Lawrence and Hamilton who depended upon a trickle of isotopes produced in the University of California cyclotron, many isotopes have become standard items in the catalogues of the biological and pharmaceutical companies.

Staff members of the Naval Hospital and the Naval Medical School investigating this problem found that the Atomic Energy Commission had, through its reactor program, generated a great deal of interest among non-governmental scientific groups in the construction of reactors. The investigators found that the Aerojet-General Nucleonics Laboratory of San Ramon, California, manufactured for sale through the Atomic Energy Commission a small self-contained reactor. Captain E. R. King, MC, USN, and Commander F. W. Chambers, Jr., MSC, USN, were ordered to this plant and additional investigation proved that this reactor could be modified to meet the needs of the Navy Medical Department and that it would not be a hazard to the health of the Medical Center population nor to the residents of the neighboring communities.

The findings of the investigators were made known to the Surgeon General of the Navy, Rear Admiral Bartholomew W. Hogan, Medical Corps, U. S. Navy, who approved a request to procure a reactor. Funds were provided by the Congress in 1956 and a contract was entered into with Aerojet-General Nucleonics Laboratory to provide the reactor and control equipment and with Southern Commercial Construction, Inc., to construct the building to house the reactor.

II. UTILIZATION

The development of the five watt medical reactor by the Aerojet-General Nucleonics Laboratory and the installation of such a reactor at the Naval Hospital makes it possible for the first time to produce short half life radioisotopes locally in close proximity to the patients in whom they will be used. By having this facility available at the hospital it will open up an entirely new field in the utilization and investigation of radioactive isotopes of short half life which will provide the same diagnostic information as the longer half life isotopes without subjecting the patients to excessive amounts of internal body radiation. These short-life isotopes include:

Sodium^{24} having a half-life of 15 hours; chlorine^{38} having a half-life of 37.3 minutes; magnesium^{56} having a half-life of 2.58 hours; zinc^{69} having a half-life of 52 minutes; and others. In addition to the manufacture of radioactive isotopes, the reactor will be used for research studies on the effects of neutron irradiation of biological materials, and for instruction of medical officers, Nurse Corps officers and enlisted Hospital Corps isotope technicians.

III. REACTOR DESIGN

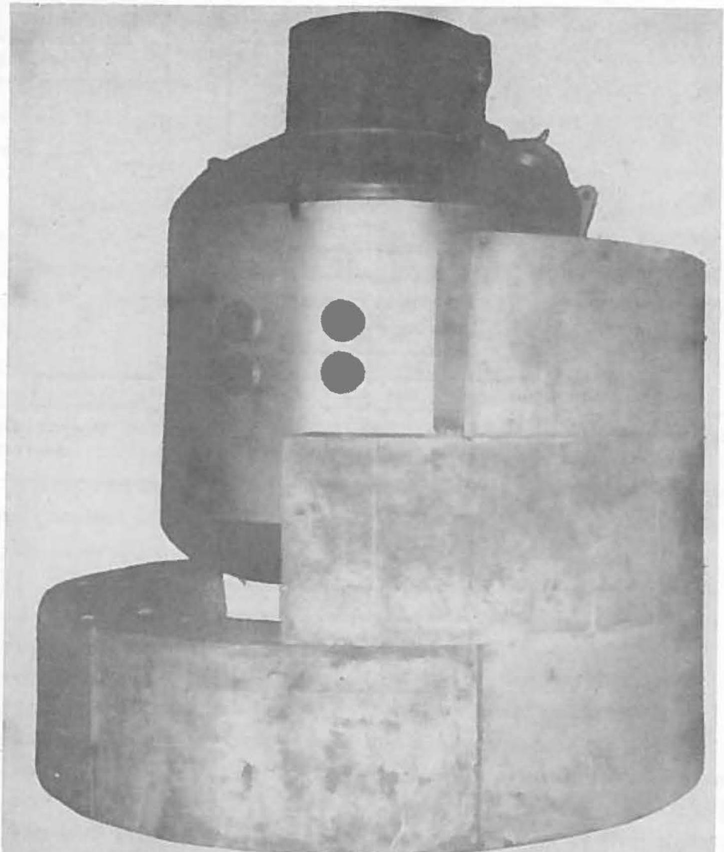
(a) The reactor selected, the AGN-201 manufactured by the Aerojet-General Nucleonics Laboratory, was modified to meet the needs of the Medical Department. An increase in power from 0.1 to 5 watts (an increase of 50 in power) greatly increased its usefulness and required only the addition of a concrete biological shield about the reactor and an increase in the scope of the neutron detectors to determine and utilize the added flux.

(b) The physical dimensions of the reactor, page 1, are 9 ft. in height and 6.5 ft. in diameter, surrounded for the increase flux by an eighteen inch concrete wall that fits about the tank as a sleeve. This wall partially assembled is shown on page 5. There is in addition to the tank and shield, a control board with the necessary instruments for control of the reactor. The reactor is housed in a 21' x 21' x 21' concrete block house, in close proximity to chemical laboratories for the handling of irradiated materials, sample counting rooms and a chemical laboratory for the preparation of the compounds before irradiation.

The reactor, shown in cross section on page 8, has the following characteristics:

Power	5 watts
Maximum Thermal Flux	$2.25 \times 10^8 n^t/cm^2/sec$
Critical Mass	3×10^3 gm U (20% enriched)
Core Size	25 cm in dia. 24 cm height
Moderator	11×10^3 gm polyethylene
Reflector	20 cm thick graphite
Shield	7.5×10^3 lb of lead
Shield	8.7×10^3 lb of water
Negative Temp. coefficient of reactivity	$-2.5 \times 10^{-4}/^oC$

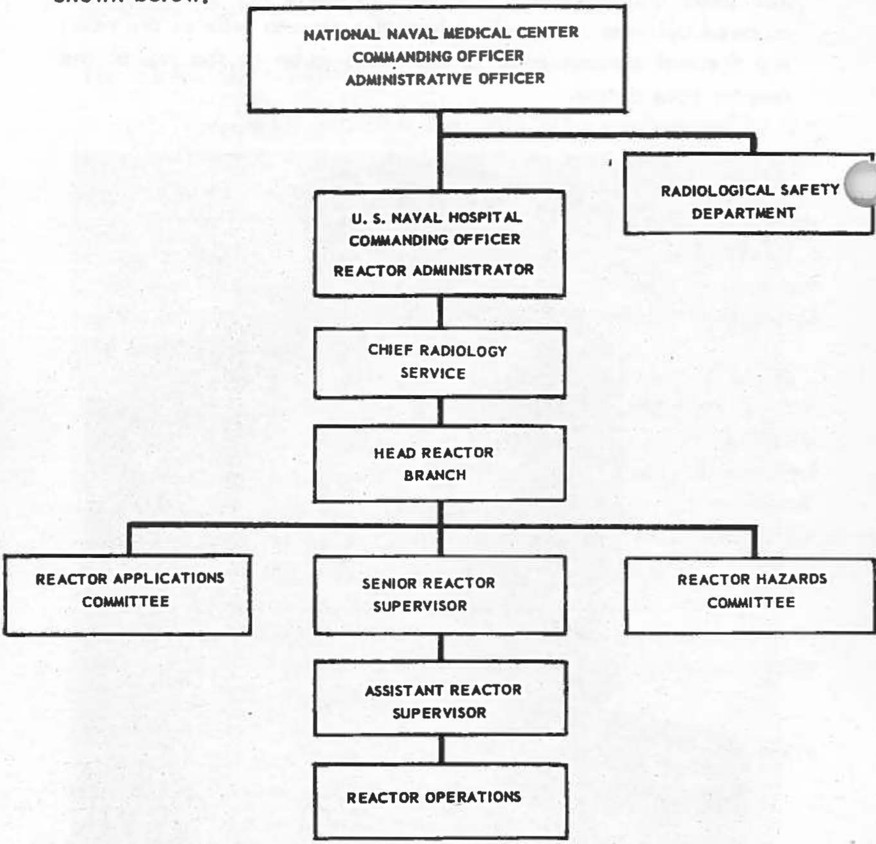
There are three positions in the reactor at which samples may be irradiated: A one inch diameter tube leading through the core on page 8, providing a ten inch length of the highest flux available; four access ports that pass tangentially to the core, each having a four inch diameter, with an efficient volume yet to be determined; and the thermal column - a graphite lined area on top of the reactor where the majority of the flux has been thermalized. The access ports are shown as the covered cylinders protruding from the smooth side of the tank; the thermal column area is the large cube at the top of the reactor core below.



Position and partial placement of the annular concrete biological shield necessary with a 5 watt power level.

IV. ORGANIZATION, LICENSING AND OPERATION

Following the decision to procure a reactor, the procedures for licensing the reactor by the Atomic Energy Commission were begun. Among the first steps was the establishment of the command organization setting up the required billets and responsibilities. The command organization chart is shown below:



Operators were selected and steps were taken for the necessary instruction leading to their licensing. To date seven operators, as shown on page iv, have been licensed by the Atomic Energy Commission. It is interesting to note that one of these, Captain E. R. King, MC, USN, is the first doctor of medicine to be approved and licensed by the Atomic Energy Commission as a nuclear reactor operator.

An application for a license to operate the reactor was submitted to the Atomic Energy Commission on 27 March 1957 and was subsequently granted on 13 Sep 1957 effective for 20 years.

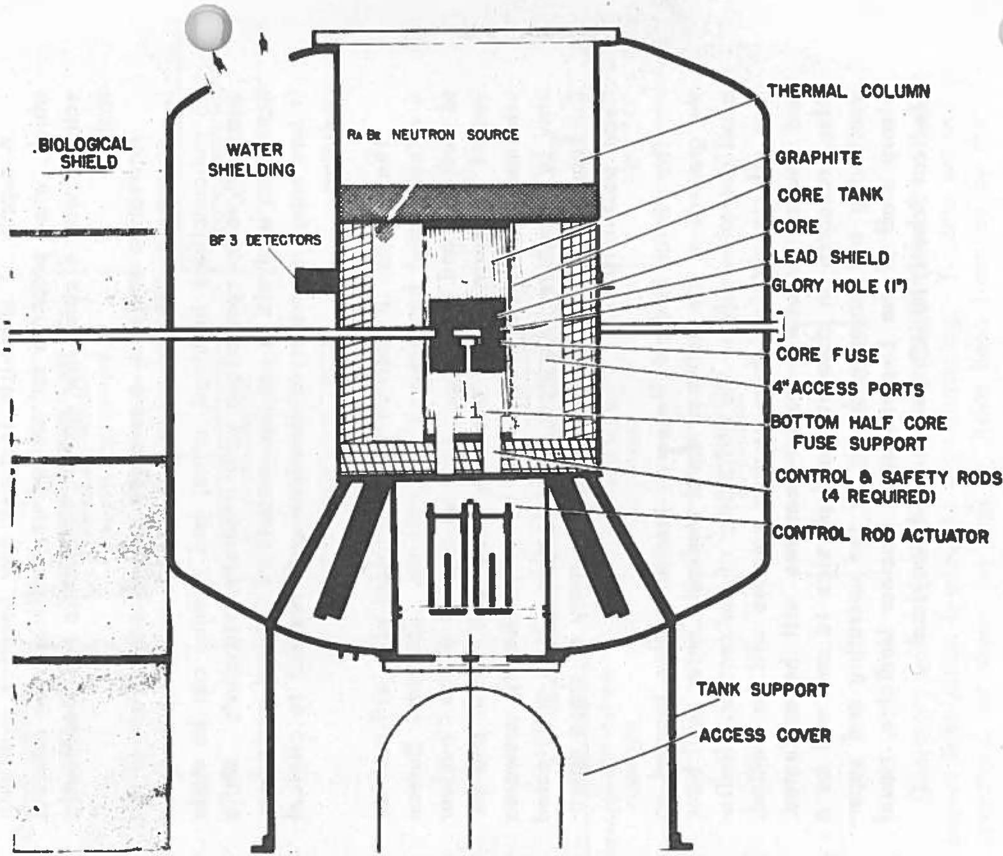
V. CONCLUSION

A supply of short-life isotopes now becomes available which, when prepared for patient use, will provide medical science with a safe, low energy, diagnostic and therapeutic tool.

Activation analysis, a research method making use of the low flux field of the reactor for the activation of as many as 15 radionuclides in blood, urine, and tissue, can be made quantitative by comparison with irradiated standards. While activation analysis is not now a standard clinical procedure, it has many important implications with respect to clinical medicine.

The reactor, in addition to the clinical use, will provide a valuable tool for research and training. The Navy Bureau of Medicine and Surgery, in keeping abreast of the "nuclear vessel" program of the fleet, is faced with health and environmental decisions that can be scientifically answered only by intensive laboratory investigation. It is anticipated the reactor will provide the answer to many of these operational possibilities.

The Naval Medical Research Institute, also located on the grounds of the National Naval Medical Center, will have a collaborative role in the utilization of the reactor. Radiation effects obtained from neutron sources will be studied, and neutron exposure counter-measures will be evaluated. Also, research in chemistry and physics is and will be a continuing and major endeavor of the operating and supervisory staff of the Department of Nuclear Medicine, Naval Medical School, NNMC, Bethesda 14, Maryland.



5 WATT REACTOR FOR MEDICINE & RESEARCH